CHAPTER III.9 COST OF REDUCING HIGH BLOOD LEAD LEVELS IN CHILDREN

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III.9.A Background

This analysis focuses solely on the medical costs associated with efforts to reduce blood lead (PbB) levels in children under the age of six. Information is provided regarding treatment, source reduction and education prescribed in response to elevated PbB levels. The chapter does **not** include medical costs of treating health effects that result from lead exposure. Cost estimates may be developed for lead-induced effects in the future (concurrent effects are discussed in more detail below). The chapter also does not include information on elements such as indirect medical costs, pain and suffering, lost time of unpaid caregivers, etc. The reader is referred to Chapter I.1 for a discussion of the cost estimation methods and cost elements that are relevant to all benefits estimates. In addition, Chapter III.1 contains information regarding the special characteristics of developmental defects, and a list of chemicals that may cause developmental abnormalities.

The costs presented in this chapter were current in the year the chapter was written. They can be updated using inflation factors accessible by clicking on the sidebar at left.

Link to Chapters I.1 and III.1
Link to inflation factors

III.9.A.1 Description

Elevated PbB levels in young children occur when children are exposed to lead via any media (i.e., air, water, food, soil). Elevated PbB in children is a considerable public health concern, due to the potential adverse effects of lead on multiple organ systems and the particular susceptibility of young children to many of these effects, including neurological damage. Lead is toxic to the kidneys and is associated with low birth weight, male sterility, cancer, and a wide array of neurological disorders. Elevated PbB may lead to neurological impairment, behavioral abnormalities, and damage to the cardiovascular, kidney, liver, gastrointestinal, blood-forming, reproductive, and endocrine systems. Lead is also a suspected carcinogen and mutagen (EPA, 1987), and impairs the immune system, causing increased susceptibility to infectious agents (ATSDR, 1997).[1]

[1] This analysis used data provided in EPA, 1985 and 1987, which contain a cost-benefit analysis of reducing lead in gasoline.

Children are particular susceptibility to neurological impairment. Lead damages the developing neurons in the brain by damaging the protective coating of myelin on nerve cells; it is suspected of causing irreversible limitations in brain function. A relationship between a decrease in cognitive functioning (as measured by IQ tests) and lead exposure in young children has been reported in numerous studies.

Elevated PbB levels are used to evaluate the level of risk and determine treatment. The Centers for Disease Control (CDC) have developed a classification system for risks to children, based on their PbB levels and a related measure of lead exposure, erythrocyte protoporphyrin (EP). Their classification system was modified in EPA (1987) and is shown in Table III.9-1. This system is used in Section B to determine treatment costs.

Table III.9-1

Condensed Version of CDC Risk Classification Table

Blood Lead Level (µg/dl)	**Erythrocyte Protoporphyrin Level (EP) (µg/dl)**		
	0-32	**33-53**	**>53**
0-20	I	Ia	Ia
21-40	Ib	II	III
>40	*	III	IV

* = not generally observed
Source: U.S. EPA (1987)

III.9.A.2 Concurrent Effects

As noted above, lead exposure may lead to a variety of adverse health effects. The occurrence of effects will depend on the levels of PbB (as reflective of exposure throughout the body), the health status of the individual (e.g., poor nutritional status is especially problematic), and individual factors. Most children in the U.S. today do not experience severe adverse health effects that are measurable. Damage to the nervous system is very difficult to quantify, especially in young children. Aside from IQ loss, this damage not usually identified except in severe lead poisoning cases. Severe lead poisoning may lead to coma and death. The form of lead is important; and organic lead, such as tetraethyl lead (TEL), has caused deaths in children.

III.9.A.3 Causality and Special Susceptibilities

Children absorb considerably more lead than adults when ingesting the same contaminated media. Adults absorb five to ten percent of dietary lead and retain little of it; young children absorb 40 to 50 percent of dietary lead and retain 20 to 25 percent of it (Oski et al., 1994). Demographic and cultural factors affecting nutrition and dietary patterns may be considered when evaluating risks and costs. As noted above, the occurrence of adverse effects depends, in part, on the health status of the individual and individual factors. Both the uptake of lead into the body (which impacts the PbB levels) and the severity of health impacts may be exacerbated by various factors including poor health and nutritional status. Elevated EP (an indicator of lead poisoning) is often associated with iron deficiency (EPA, 1987). Diets high in fat and low in calcium, magnesium, iron, zinc, and copper increase the absorption of lead (Oski et al., 1994). Lead is stored in the body primarily in bone and may be released, causing toxicity, over many decades.

III.9.A.4 Treatments and Services

The treatments and services provided for children with elevated PbB depend on their risk classification, as shown in Table III.9-1. Detailed treatment descriptions are provided in Section B of this chapter along with cost data, and so are not presented here.

Link to Table III.9-1

III.9.A.5 Prognosis

Elevated PbB levels can always be brought down over time. The prognosis for health effects related to the elevated levels is more serious. The prognosis for full and unimpaired recovery depends on the degree of lead poisoning that occurred (e.g., the risk classification), the amount of time during which the PbB levels were elevated, the age of the child, general health and nutrition status, the degree of intervention (including special education strategies provided), and individual factors. It is not possible to predict the outcomes for individual children, due to the variety of factors which impact the final outcome. High risk children (as determined by the CDC classification system) are generally more likely to experience permanent damage than children with moderate or low risk levels.

PbB levels greater than 10 to 15 ug/dL sustained during early childhood carry a substantial risk for long-lasting but subtle injury to the nervous system, even if no clinical symptoms are detected. Attention deficits and reading disabilities have been observed in cohorts of young children with elevated PbB levels. In adults with elevated PbB as children, increased rates of dropping out and having long-term reading disabilities have been observed. When levels are very high and encephalopathy has resulted, serious sequelae may occur in later years that include seizure disorders, mental disorders, and (in some rare cases) blindness and hemiparesis. In some cases, residential care is required (Oski et al., 1994).

III.9.B Costs of Treatments and Services

III.9.B.1 Methodology

To estimate the average costs of testing and treating children with high PbB levels, this analysis relies heavily on methodologies developed for the benefit-cost analysis of reducing lead in gasoline (U.S. EPA, 1985) and later applied by the EPA's Office of Air Quality Planning and Standards (U.S. EPA, 1987).

The average direct cost per child with high PbB levels was calculated in four steps:

- a typical treatment profile was developed for each risk level,
- the costs of relevant treatments were determined,
- the costs of treatments were combined with the treatment profiles to produce an estimate of the average cost per child, and
- the costs were reduced to reflect the fact that only a portion of children with high PbB levels will be screened.

III.9.B.2 Treatment Profile and Costs by Risk Level

The costs of relevant treatment elements (e.g., chelation therapy, neuropsychological evaluation, family education) were estimated by U.S. EPA (1985) and adjusted in U.S. EPA (1987). These costs are based on the CDC's (1978) recommended clinical management program and are linked to the risk level by determining PbB and EP levels (See Table III.9-1).

Link to Table III.9-1

The treatment profile is developed at the age at which the child is first screened. This analysis considers the cost of follow-up through age five regardless of the age of the child at the initial screening. Consequently, the actual costs for children initially screened at older ages may differ from those estimated in this chapter. They may be greater or lesser, depending on the medical consequences of later screening. In addition, treatment is still likely to take place when screening occurs later in childhood, so overall costs may not be reduced regardless of the screening results. It was assumed that the distribution of the ages of children screened is uniform over the ages one through five. The cost of follow-up tests are adjusted accordingly.

Regardless of the age of initial screening, follow-up testing of children is assumed to continue through age five. A child initially screened at age one will therefore have follow-up tests for five years (ages one to five, including the initial screening year), while a child initially screened at age five will have follow-up tests only in the year of screening. The cost estimates presented below, given in 1996$, are averages for all screened children in the risk group regardless of the age at which they were initially screened.

Risk Level I. Children in this risk group are considered to be at low risk. Because screening is concentrated on children in areas with high-risk factors, follow-up treatment and family education are recommended. The estimate of the average (undiscounted) cost per child at this risk is $522.

Risk Level Ia. Children in this risk group do not have elevated PbB levels. They do have elevated EP levels, which may be indicative of iron deficiency or other medical problems. In addition to initial testing, all children at this risk level are tested for iron deficiency, at a cost of $39. The cost of medication for anemia is estimated as $127. With a mean population PbB of 20, 23.8 percent of those classified in risk level Ia will receive the medication, resulting in an average cost of $29 per child. The percentage of the children testing positive for anemia will vary with the mean population PbB concentration; a higher mean population would increase the percentage of children testing positive, and would therefore increase the average treatment costs per child. Health education, stressing nutritional needs, is assumed to be provided to 50 percent of the families with children in this risk group. The average (undiscounted) costs per screened child at this risk level is $692.

Risk Level Ib. In addition to the initial screening, children in risk category Ib receive periodic follow-up tests and limited family education. Table III.9-2. shows an estimated average (undiscounted) cost for this risk group of $623.

Risk Level II. As can be seen from Table III.9-2, children at moderate risk receive no chelation therapy. Also, no neuropsychological evaluation is performed and family education is limited. The major cost for this group comes from follow-up tests. The estimated average (undiscounted) cost for screened children in risk level II is $1,205.

Risk Level III. The treatment for children in risk level III is similar to treatment for children in risk level IV. For risk level III, however, a $CaNa_2$-EDTA provocation test is included. This test is used to evaluate the responsiveness of the child to chelation therapy. Also, the costs of chelation treatment fall sharply compared with children in risk level IV, due to the decreased percentage of children estimated to need this therapy. Only 0.43 percent of risk level III children are assumed to require this therapy, as compared with 37 percent of children in risk level IV. The cost of follow-up tests also decreases, since the frequency of follow-up tests is higher for children who have received chelation therapy than for children who have not. The estimated average (undiscounted) cost for screened children who are in risk level III is $2,632.

Risk Level IV. As can be seen from the table, the major cost element for children in the urgent risk group is chelation therapy. The probability of requiring chelation therapy increases with PbB concentrations. EPA (1987) estimated that 37 percent of the children in this risk group would require chelation therapy, based on a mean population PbB level of 20 µg/dl. Note that the cost of treatment for children in this risk group depends on this assumption regarding mean population PbB levels. A higher mean population PbB level would result in a greater percentage of children in this risk group requiring chelation therapy. Cost estimates for this risk group would therefore increase.

EPA reports that in some cases, an initial chelation therapy may be followed by a rebound in PbB levels as the body attempts to equilibrate between lead in soft tissue and lead in blood. A second and sometimes a third chelation treatment is therefore necessary. Fifty percent of children who receive one chelation treatment are assumed to require a second treatment. Fifty percent of children requiring a second chelation treatment are assumed to require a third. The total average (undiscounted) cost of treating a child in risk level IV is estimated to be $5,200.

Typical treatment for children in each risk level is shown in Table III.9-2, along with the associated average costs per screened child in each risk level.

Table III.9-2
Average Direct Cost of Treatment per Screened Child

Year	Treatment	Cost Per Child (1996 $) Level IV	Level III	Level II	Level Ib	Level Ia	Level I
Year of screening	Chelation, inpatient	1,486	13	0	0	0	0
	2nd chelation, inpatient	743	5	0	0	0	0
	3rd chelation, inpatient	372	3	0	0	0	0
	Initial lab test	61	61	61	61	61	61
	$CaNa_2$ provocation test	0	221	221	0	0	0
	Iron deficiency test	0	0	0	0	39	0
	Medication for anemia	0	0	0	0	29	0
	Follow-up tests	570	481	481	120	120	120
	Neuropsychological evaluation	1,204	1,204	0	0	0	0
	Family education	401	401	200	200	200	101
	Total	4,837	2,390	964	382	450	281
2nd year	Follow-up tests	145	97	97	97	97	97
3rd year	Follow-up tests	108	72	72	72	72	72
4th year	Follow-up tests	72	48	48	48	48	48
5th year	Follow-up tests	36	25	25	25	25	25
TOTAL		5,200	2,632	1,205	623	692	522

Totals may not add due to rounding.
Sources: U.S. EPA, 1987, Bureau of Labor Statistics.

III.9.B.3 Average Treatment Costs

To determine the average costs per child it was first necessary to estimate what percent of children in each risk category are screened. The percent of children who are placed in each risk category based on the screening results were then estimated. The risk level was used to determine the percent of patients receiving each type of treatment.

For children in risk levels III and IV, it was assumed that the lead exposure would result in behavioral symptoms; therefore, all children in these risk levels would be screened. The average cost per screened child in risk levels III and IV was assumed to equal the average cost per child in these risk groups.

Children in the lower risk categories may not develop obvious symptoms and may not receive treatment. U.S. EPA (1987) has estimated that 20 percent of children are screened for blood lead levels in any one year. A probability analysis could be performed to estimate the likelihood of a child being treated between disease onset and the age of six. Costs could then be adjusted based on the predicted average years past onset that screening occurs, but the level of detail of the information available on frequency of screening does not warrant this detailed analysis. As a simple and approximate method of accounting for the fact that not all children with high PbB levels are screened, the treatment costs for children in risk categories II, I, IA, and IB are multiplied by 0.2. The estimated costs for each risk level are shown in Table III.9-3.

Table III.9-3

Average Direct Costs per Child With High Blood Lead Levels--All Risk Groups[a] (1996 $)

Risk Level Per Child	Cost per Disease Year (1996 $) 1	2	3	4	5	Total Cost (1996 $)
IV	4,837	145	108	72	36	5,200
III	2,390	97	72	48	25	2,632
II[b]	193	19	14	10	5	241
Ib[b]	77	19	14	10	5	125
Ia[b]	90	19	14	10	5	138
I[b]	56	19	14	10	5	105

[a] Assuming uniform distribution of the tested children over ages 1 through 5.
[b] As explained in the text, cost estimates for these risk categories have been multiplied by 0.20 to reflect the percentage of children expected to be screened. If it is assumed that all children who need services will receive them, then the values reported in Table III.9-3 for Levels I and II should be used.
Source: U.S. EPA, 1987.

III.9.B.4 Survival

No data linking survival rates to elevated blood lead levels were found. This analysis assumes, therefore, that survival rates match typical survival rates in the entire U.S. population. The calculated survival rates for disease years one through five for children ages one to five, however, are 100 percent, as reported in *Vital Statistics of the United States* (U.S. Department of Health and Human Services, 1985). Survival rates therefore have no impact on the cost estimates.

III.9.B.5 Present Value Costs

Table III.9-4 shows the discounted direct cost estimates in Table III.9-3. Estimates of the present value costs per child with high PbB levels are shown in Table III.9-4, using discount rates of zero, three, five, and seven percent. Using a five percent discount rate, estimates of the net present value of medical costs per child with high blood levels are $5,162 for risk level IV, $2,610 for risk level III, $237 for risk level II, $120 for risk level Ib, $134 for risk level Ia, and $101 for risk level I. The discount rates have only a minor impact on the present value cost estimates, due to the fact that the majority of costs are incurred in the year of screening and are therefore unaffected by the discount rates.[2]

[2] Screening may not be coincident with onset of high PbB levels; no information was located regarding a typical time period between onset of high PbB levels and screening. If such information was available, then the costs of the disorder could be discounted over this lag period.

Table III.9-4

Discounted Average Direct Costs per Child Age One to Five Years with High Blood Lead Levels (1996 $)

Risk Level	Discounted Per Patient Costs (Discount Rate %)			
	0	3	5	7
IV	5200	5185	5162	5135
III	2632	2623	2610	2591
II	241	240	237	234
Ib	125	123	120	117
Ia	138	137	134	132
I	105	104	101	97

Sources: U.S. EPA, 1987, Bureau of Labor Statistics.

The costs presented in this chapter were current in the year the chapter was written. They can be updated using inflation factors accessible by clicking below.

Link to inflation factors

Lead exposure analyses can produce estimates of the distribution of PbB levels and EP levels among the population, and therefore the distribution of the population among the risk levels shown in Table III.9-1. This distribution can be compared to levels of PbB and EP in the population under various regulatory options to estimate the change in the number of individuals in each of the risk categories. By multiplying the change in the number of individuals in each risk category by the costs of screening and treating an individual in that risk category and summing over all risk categories, the benefits of the regulations may be calculated.

Link to Table III.9-1

III.9.B.6 Limitations

There are numerous limitations to the cost estimates provided in this chapter. Foremost is the restriction of the information to those costs associated directly with the reduction of lead levels in blood. As discussed in Section III.9.A, numerous serious concurrent effects occur as a result of elevated blood lead levels. These effects are the reason that time and money are spent to reduce blood lead level in children. The costs of their treatment may be substantial. Some children may not experience measurable (or any) consequences of elevated blood lead levels, particularly if the elevations are very small, the children are healthy, and they have a good nutritional status.

Another major limitation is the assumption that only 20 percent of children are tested, valued when the chapter was originally written in 1993. There has since been an increased awareness of the risks associated with lead poisoning in children and a concurrent increase in the testing of young children, which will lead to an increase in both testing and treatment costs. The costs presented in this chapter are therefore an underestimate of actual costs.

Another limitation is the lack of data regarding the age at which testing is performed. As stated in the text, testing may not be done at the age of one year. If it is done later, the costs of treatment may be greater or less than those estimated here. Costs would be lower if only minimal treatment were required because they would extend over a shorter period. If a delay in testing led to higher levels requiring more complex treatment and long-term impairment, then the costs could be much higher.

Finally, the cost estimates in this chapter are based largely on a methodology and data that were collected in the 1980s. These data may be outdated if new protocols are in place, and the costs may therefore differ from those presented here.